

Patent Claims

1. A method for determination of the stressing force in connecting components (1) by ultrasound injection by means of a programmable arbitrary function generator (AFG), having the following method steps:

a) an electrical pulse (7) with a predetermined pseudo-static phase angle of the used and/or predetermined frequency components is generated with an essentially constant amplitude and a predeterminable pulse width at the programmable arbitrary function generator (AFG),

b) the chosen pulse width is matched to the intervals between ultrasound pulse echoes (8) in such a manner that there is no overlap between individual different reflections,

c) the received ultrasound pulse echo (8) is selected in time with respect to at least one reflection and is subjected to a transformation process which is defined for the respective connecting component (1), in such a manner that all of the frequency contributions of the frequency components are shifted in time or with respect to the phase for a defined time which is related to the ultrasound pulse (7), such that

d) for this time and in the absence of the prestressing force, the phase angle is always 0 or the phase angle is always π when cosine functions are used to represent the frequency components.

2. A method for determination of the stressing force in connecting components (1) by ultrasound injection by means of a programmable arbitrary function generator (AFG), having the following method steps:

a) an electrical pulse (7) in the form of a linear chirp of the used and/or predetermined frequency components with an essentially constant amplitude and a predeterminable pulse width is generated at the programmable arbitrary function generator (AFG),

b) the chosen pulse width is matched to the intervals between ultrasound pulse echoes (8) in such a manner that there is no overlap between individual different reflections,

c) the received ultrasound pulse echo (8) is selected in time with respect to at least one reflection and is subjected to a transformation process which is defined for the respective connecting component (1) , in such a manner that all of the frequency contributions of the frequency components are shifted in time or with respect to the phase for a defined time which is related to the ultrasound pulse (7) , such that

d) for this time and in the absence of the prestressing force, the phase angle is always 0 or the phase angle is always Π when cosine functions are used to represent the frequency components.

3. A method for determination of the stressing force in connecting components (1) by ultrasound injection by means of a programmable arbitrary function generator (AFG), having the following method steps:

a) an electrical pulse (7) as pseudo-random noise on the used and/or predetermined frequency components is generated with an essentially constant amplitude and a predeterminable pulse width at the programmable arbitrary function generator (AFG)

b) the chosen pulse width is matched to the intervals between ultrasound pulse echoes (8) in such a manner that there is no overlap between individual different reflections,

c) the received ultrasound pulse echo (8) is selected in time with respect to at least one reflection and is subjected to a transformation process which is defined for the respective

connecting component (1), in such a manner that all of the frequency contributions of the frequency components are shifted in time or with respect to the phase for a defined time which is related to the ultrasound pulse (7), such that

d) for this time and in the absence of the prestressing force, the phase angle is always 0 or the phase angle is always Π when cosine functions are used to represent the frequency components.

4. The method as claimed in claim 2, characterized in that the timing of the centroid of the frequency contributions with respect to the frequency is a continuous function over the pulse width that is used.

5. The method as claimed in claims 1, 2 or 3, characterized in that the pulse center; the pulse start or the pulse end is chosen in accordance with method step c) as the defined time which is related to the ultrasound pulse (7).

6. The method as claimed in claims 1, 2 or 3, characterized in that frequency contents are distributed over a large number of successive ultrasound pulses (7) in accordance with method step a).

7. The method as claimed in claim 6, characterized in that the frequency contents are distributed over 2 to 100 ultrasound pulses (7).

8. The method as claimed in claims 6 or 7, characterized in that measurements over individual frequency range elements in the frequency spectrum of the ultrasound pulse (7) are

combined, from which a short signal which is obtained from all of the individual contributions is synthesized.

9. The method as claimed in claims 1, 2 or 3, characterized in that the ultrasound pulse (7) has a maximum excitable ultrasound frequency spectrum, with which a spectrum with the maximum excitable bandwidth is excited.

10. The method as claimed in claims 1, 2 or 3, characterized in that the ultrasound pulse (7) is generated by an arbitrary function generator (AFG) or DDS chips (dynamic digital synthesis) or VCOs (voltage controlled oscillators) which are switched on and off at the same time, and a digitizing transient recorder (TR) is used for detection of the ultrasound pulse echo (8).

11. The method as claimed in claim 10, characterized in that the arbitrary function generator (AFG) and the transient recorder (TR) are controlled by the same clock transmitter (TG).

12. The method as claimed in claim 11, characterized in that a repetition rate for the respective individual measurements is derived from the clock transmitter (TG).

13. The method as claimed in claim 9, characterized in that, in a number of successive and repeated ultrasound pulses (7), a supplementary bandwidth is used in each case which corresponds to the reciprocal of the number of ultrasound pulses (7), is different and is mutually exclusive.

14. The method as claimed in claims 1, 2 or 3, characterized in that the excitation voltage is kept at a minimum by excitation over an extended time, thus lengthening the life of the transducer (5).

15. An apparatus for carrying out the method as claimed in one or more of the preceding claims, characterized in that this apparatus contains a processor or a microprocessor, and has a programmable arbitrary function generator (AFG) as well as a digitizing transient recorder (TR) with a connection to the processor or to the microprocessor, and a repetition rate generator (RG).

16. The apparatus as claimed in claim 15, characterized in that the arbitrary function generator (AFG) and the transient recorder (TR) are operated with one and the same clock transmitter (TG).

17. The apparatus as claimed in claim 15, characterized in that the arbitrary function generator (AFG), the transient recorder (TR) and the repetition rate generator (RG) are operated with a common clock transmitter (TG).

18. The apparatus as claimed in claims 15, 16 or 17, characterized in that the arbitrary function generator (AFG) is followed by a power amplifier.

19. The apparatus as claimed in claims 15, 16 or 17, characterized in that the transient recorder (TR) is preceded by a preamplifier or by a programmable-gain preamplifier with a connection to the computer.

20. The apparatus as claimed in claims 15, 16 or 17, characterized in that the processor or the microprocessor is contained in a personal computer (PC) or in a laptop.